



Testimony

Before the Subcommittee on Tactical Air
and Land Forces, Committee on Armed
Services, House of Representatives

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JOINT STRIKE FIGHTER

Restructuring Added Resources and Reduced Risk, but Concurrence Is Still a Major Concern

Statement of Michael J. Sullivan, Director
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Why GAO Did This Study

The F-35 Lightning II, also known as the JSF, is DOD's most costly and ambitious aircraft acquisition, seeking to simultaneously develop and field three aircraft variants for the Air Force, Navy, Marine Corps, and eight international partners. The JSF is critical to DOD's long-term recapitalization plans as it is intended to replace hundreds of legacy aircraft. Total U.S. investment in the JSF is nearing \$400 billion to develop and procure 2,457 aircraft over several decades and will require a long-term, sustained funding commitment. In 2010, DOD began to extensively restructure the program to address relatively poor cost, schedule, and performance outcomes.

This testimony draws on GAO's extensive body of work on the JSF, including preliminary results from the current annual review mandated in the National Defense Authorization Act for Fiscal Year 2010. This testimony discusses (1) program costs, schedule changes, and affordability issues, (2) performance testing results, software, and technical risks, and (3) procurement contract cost performance, concurrency impacts, manufacturing results, and design changes. GAO's work included analyses of a wide range of program documents and interviews with defense and contractor officials.

What GAO Recommends

GAO has made prior recommendations to help reduce risk and improve outcomes, which DOD has implemented to varying degrees. GAO's forthcoming report will address these in detail along with potential new recommendations.

View [GAO-12-525T](#). For more information, contact Michael J. Sullivan at (202) 512-4841 or sullivanm@gao.gov.

March 20, 2012

JOINT STRIKE FIGHTER

Restructuring Added Resources and Reduced Risk, but Concurrency Is Still a Major Concern

What GAO Found

Joint Strike Fighter (JSF) restructuring continues into a third year, adding to cost and schedule. Since June 2010, the total cost estimate increased about \$15 billion, \$5 billion for development and \$10 billion for procurement. There will likely be additional changes when the Department of Defense (DOD) approves a new program baseline, expected soon. Compared to the current approved baseline from 2007, total costs have increased about \$119 billion, full-rate production has been delayed 5 years, and initial operational capability dates are now unsettled because of program uncertainties. While the total number of aircraft the U. S. plans to buy has not changed, DOD has for 3 straight years reduced near-term procurement quantities, deferring aircraft and costs to future years. Since 2002, the program has reduced aircraft procurement quantities through 2017 by three-fourths, from 1,591 to 365. As the program continues to experience cost growth and delays, projected annual funding needs are unprecedented, averaging more than \$13 billion a year through 2035.

Most of the instability in the program has been and continues to be the result of highly concurrent development, testing, and production. Overall performance in 2011 was mixed as the program achieved 6 of 11 primary objectives. Developmental flight testing gained momentum and is about one-fifth complete with the most challenging tasks still ahead. The program can expect more changes to aircraft design and manufacturing processes. Performance of the short takeoff and vertical landing variant improved this year and its "probation" period to fix deficiencies was ended early, even though several fixes are temporary and untested. Management and development of the more than 24 million lines of software code continue to be of concern and late software releases have delayed testing and training. Development of the critical mission systems that give the JSF its core combat capabilities remains behind schedule and risky. To date, only 4 percent of the mission system requirements for full capability has been verified. Testing of a fully integrated JSF aircraft is now expected in 2015 at the earliest. Deficiencies with the helmet mounted display, integral to mission systems functionality and concepts of operation, are most problematic. DOD is funding a less-capable alternate helmet as a back-up. The autonomic logistics information system, a key ground system for improving aircraft availability and lowering support costs, is not yet fully developed.

Cost overruns on the first four annual procurement contracts total more than \$1 billion and aircraft deliveries are on average more than one year late. Officials said the government's share of the cost growth is \$672 million; this adds about \$11 million on average to the price of each of the 63 aircraft under those contracts. In addition to the overruns, the government also incurred an estimated \$373 million in retrofit costs on produced aircraft to correct deficiencies discovered in testing. The manufacturing process is still absorbing a higher than expected number of engineering changes resulting from flight testing, which makes it difficult to achieve efficient production rates. Until engineering changes are reduced, there are risks of additional cost overruns and retrofit costs. The program now estimates that the number of changes will persist at elevated levels through 2019. Even with the substantial reductions in near-term procurement quantities, DOD is still investing billions of dollars on hundreds of aircraft while flight testing has years to go.

Chairman Bartlett, Ranking Member Reyes, and Members of the Subcommittee:

Thank you for the opportunity to discuss our work on the F-35 Lightning II, also known as the Joint Strike Fighter (JSF). The JSF is the Department of Defense's (DOD) most costly and ambitious aircraft acquisition, seeking to simultaneously develop and field three aircraft variants for the Air Force, Navy, Marine Corps, and eight international partners. The JSF is critical to DOD's long-term recapitalization plans as it is intended to replace hundreds of legacy fighters and strike aircraft. Total U.S. investment in the JSF will be substantial—approaching \$400 billion to develop and acquire 2,457 aircraft over the next few decades—and will require a long-term sustained funding commitment. Over the last 2 years, the JSF program has been extensively restructured to address relatively poor cost, schedule, and performance outcomes.

We have reported on JSF issues for a number of years.¹ A recurring theme in our body of work since 2005 has been a concern about the substantial concurrency, or overlap, of JSF development, test, and production activities and the heightened risk it poses to achieving good program outcomes. The effects of concurrency became apparent in 2011 as the JSF program incurred an estimated \$373 million in additional costs to retrofit already-built aircraft to correct deficiencies discovered during testing. Our prior reports have also made numerous recommendations for reducing risks and improving chances for successful outcomes. DOD has agreed with and taken actions on these recommendations to varying degrees. More detail on the status of these prior recommendations will be provided in our forthcoming report. In April 2011, we reported that the department's restructuring actions should lead to more achievable and predictable outcomes, albeit at higher costs and with extended times to test and deliver capabilities to the warfighter.² The report also identified continuing issues concerning affordability risks (both for acquiring JSF aircraft and supporting them over the life-cycle), delays in software development, a continued high rate of design changes, and immature manufacturing processes.

¹ See related GAO products at the end of this statement.

² GAO, *Joint Strike Fighter: Restructuring Places Program on Firmer Footing, but Progress Still Lags*, [GAO-11-325](#) (Washington, D.C.: Apr. 7, 2011).

This testimony is largely based on preliminary results from our latest review. The National Defense Authorization Act for Fiscal Year 2010³ requires GAO to review the JSF program annually for 6 years. We plan to issue our detailed report in April to incorporate new baseline cost and schedule data. My testimony will address (1) program cost and schedule changes and their implications on affordability; (2) performance testing results and technical risks; and (3) contract cost performance, concurrency impacts, and design and manufacturing maturity. To conduct this work, we reviewed program status reports, manufacturing data, contracts, test plans and performance, and internal DOD analyses. We evaluated restructuring actions and impacts, tracked cost and schedule changes, and identified factors driving the changes. We discussed program results to date and future plans with officials from the Office of the Secretary of Defense (OSD), JSF program office, military services, other defense offices, and contractors. We toured aircraft and engine manufacturing plants, obtained production and supply performance indicators, and discussed improvements underway with contractors. We discussed the information used to prepare this testimony with DOD officials and included their comments as appropriate. We conducted this performance audit from June 2011 to March 2012 in accordance with generally accepted government auditing standards. Those standards required that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Restructuring Reduces Near Term Risk, but Long Term Affordability Is Challenging

JSF restructuring continued throughout 2011 and into 2012 with additional costs and extended schedules incurred for key activities and decisions. The Department's actions have helped reduce near term risks by lowering annual procurement quantities and allowing more time for flight testing. The Department is expected to soon approve a new acquisition program baseline that will likely make further changes in cost and schedule. This decision, critical for program management and oversight, has been delayed several times and it has now been 2 years since the Department announced that the JSF program had breached the

³ Pub. L. No. 111-84 § 244 (2009).

critical cost growth statutory thresholds⁴ and that a new baseline would be established. Table 1 tracks historical changes in cost, schedule, and quantities since the start of development (2001), a major redesign (2004), a new baseline following the program's Nunn-McCurdy breach of the significant cost growth statutory threshold (2007), initial restructuring actions after the second Nunn-McCurdy breach (2010), and an interim DOD cost estimate (2011).

⁴ Commonly referred to as Nunn-McCurdy, 10 U.S.C. § 2433 establishes the requirements for DOD to submit unit cost reports on major defense acquisition programs or designated major subprograms. Two measures are tracked against the current and original baseline estimates for a program: procurement unit cost (total procurement unit funds divided by the quantity of systems procured) and program acquisition unit cost (total funds for development, procurement, and system-specific military construction divided by the quantity of systems procured). If a program's procurement unit cost or acquisition unit cost increases by at least 25 percent over the current baseline estimate or at least 50 percent over the original baseline estimate, it constitutes a breach of the critical cost growth threshold. Programs are required to notify Congress if a Nunn-McCurdy breach is experienced. When a program experiences a Nunn-McCurdy breach of the critical cost growth threshold, DOD is required to take a number of steps, including reassessing the program and submitting a certification to Congress in order to continue the program, in accordance with 10 U.S.C. § 2433a.

Table 1: JSF Program Cost and Quantity Estimates over Time

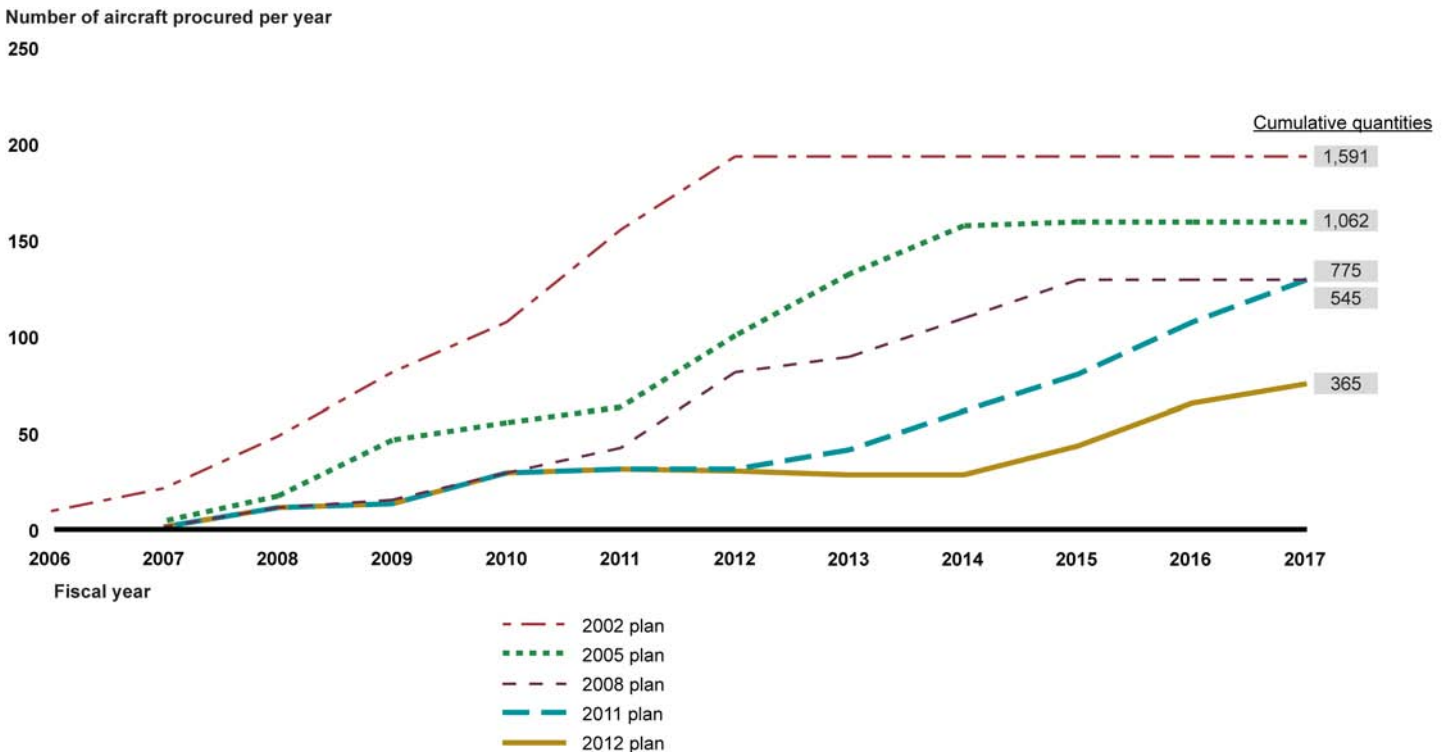
	October 2001 (system development start)	December 2003 (2004 replan)	March 2007 (approved baseline)	June 2010 (Nunn-McCurdy)	June 2011 (interim DOD estimate)
Expected quantities					
Development quantities	14	14	15	14	14
Procurement quantities (U.S. only)	2,852	2,443	2,443	2,443	2,443
Total quantities	2,866	2,457	2,458	2,457	2,457
Cost estimates (then-year dollars in billions)					
Development	\$34.4	\$44.8	\$44.8	\$51.8	\$56.6
Procurement	196.6	199.8	231.7	325.1	335.6
Military construction	2.0	0.2	2.0	5.6	4.9
Total program acquisition	\$233.0	\$244.8	\$278.5	\$382.5	\$397.1
Unit cost estimates (then-year dollars in millions)					
Program acquisition	\$81	\$100	\$113	\$156	\$162
Average procurement	69	82	95	133	137
Estimated delivery and production dates					
First production aircraft delivery	2008	2009	2010	2010	2011
Initial operational capability	2010-2012	2012-2013	2012-2015	TBD	TBD
Full-rate production	2012	2013	2013	2016	2018

Source: GAO analysis of DOD data.

The interim total program cost estimate increased about \$15 billion since the June 2010 estimate included in the Nunn-McCurdy certification, about \$5 billion for development and \$10 billion for procurement. Compared to the current approved baseline set in 2007, total costs have increased about \$119 billion, unit procurement costs have risen more than 40 percent, and the start of full-rate production has been delayed 5 years. The department anticipates releasing its new cost and schedule estimates within the next few weeks. Department officials have indicated that the new figures will not be significantly different from the June 2011 interim estimate. Initial operational capability dates for the Air Force, Navy and Marine Corps—the critical dates when the warfighter expects the capability promised by the acquisition program to be available—have been delayed over time and are now unsettled. Until greater clarity is provided on the program’s path forward, the military services are likely to wait to commit to new initial operational capability dates.

Concerned about concurrency risks, in February 2012, DOD reduced planned procurement quantities through fiscal year 2017 by 179 aircraft. This marked the third time in 3 years that near-term quantities were cut; combined with other changes since 2008, total JSF procurement quantity has been reduced by 410 aircraft through fiscal year 2017. Since the department still plans to eventually acquire the full complement of U.S. aircraft—2,443 procurement jets—the procurement costs, fielding schedules, and support requirements for the deferred aircraft will be incurred in future years beyond 2017. Figure 1 shows how planned quantities in the near-term have steadily declined over time. With the latest reduction, the program now plans to procure a total of 365 aircraft through 2017, about one-fourth of the 1,591 aircraft expected in the 2002 plan.

Figure 1: Changes in Procurement Plans over Time



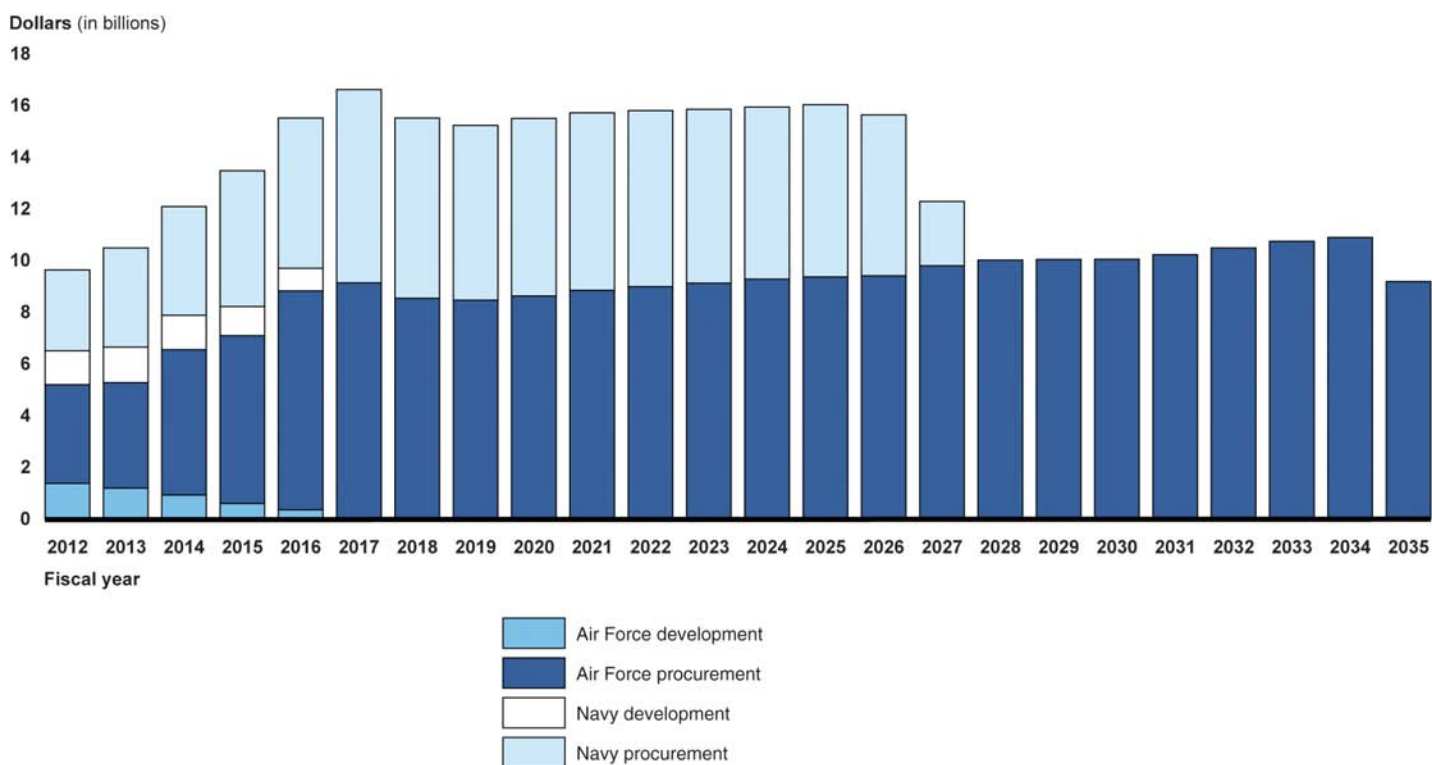
Source: GAO analysis of DOD data.

Slowing down procurement plans reduces concurrency risks to a degree, but overall program affordability—both in terms of the investment costs to acquire the JSF and the continuing costs to operate and maintain it over

the life-cycle—remains a major risk. The long-stated intent that the JSF program would deliver an affordable, highly common fifth generation aircraft that could be acquired in large numbers could be in question. As the JSF program moves forward, unprecedented levels of funding will be required during a period of more constrained defense funding expectations overall. As shown in figure 2, the JSF annual funding requirements average more than \$13 billion through 2035, and approach \$16 billion annually for an extended period. The Air Force alone needs to budget from \$8 to \$11 billion per year from fiscal year 2016 through 2035 for procurement.⁵ At the same time, the Air Force is committed to other big-dollar projects such as the KC-46 tanker and a new bomber program.

⁵ This is based on information contained in the December 2010 Selected Acquisition Report. Updated funding information for the entire JSF acquisition life-cycle was not available at the time of this testimony. The new baseline information is expected to add to JSF total costs through completion and change the distribution of annual budget requirements, but still show very large budget demands over a long period of time.

Figure 2: JSF Budgeted Development and Procurement Funding Requirements



Source: GAO analysis; JSF Selected Acquisition Report (December 2010).

Mixed Performance in 2011 Affected by Concurrency and Technical Risks

Much of the instability in the JSF program has been and continues to be the result of highly concurrent development, testing, and production activities. During 2011, overall performance was mixed as the program achieved 6 of 11 primary objectives for the year. Developmental flight testing has recently gained momentum, but has a long road ahead with testing of the most complex software and advanced capabilities still in the future. JSF software development is one of the largest and most complex projects in DOD history, providing essential capability, but software has grown in size and complexity, and is taking longer to complete than expected. Developing, testing, and integrating software, mission systems, and logistics systems are critical for demonstrating the operational effectiveness and suitability of a fully integrated, capable aircraft and pose significant technical risks moving forward.

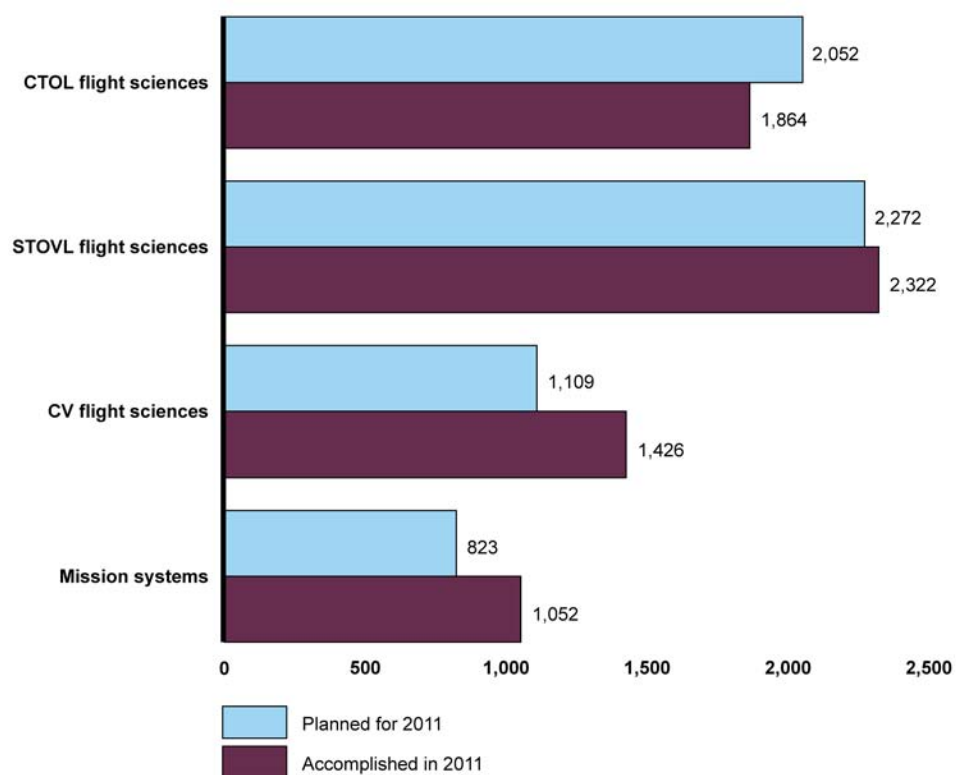
Program Performance against 2011 Objectives and Test Plans Was Mixed

The JSF program achieved 6 of 11 primary objectives it established for 2011. Five of the objectives were specific test and training actions tied to contractual expectations and award fees, according to program officials. The other 6 objectives were associated with cost, schedule, contract negotiations, and sustainment. The program successfully met 2 important test objectives: the Marine Corps' short takeoff and vertical landing (STOVL) variant accomplished sea trials and the Navy's carrier variant (CV) completed static structural testing. Two other test objectives were not met: the carrier variant did not demonstrate shipboard suitability because of problems with the tail hook, which requires redesign, and software was not released to flight test on time. The program also successfully completed objectives related to sustainment design reviews, schedule data, manufacturing processes, and cost control, but did not meet a training deadline or complete contract negotiations.

Development flight testing sustained momentum begun in 2010 and met or exceeded most objectives in its modified test plan for 2011. The program accomplished 972 test flights in 2011, more than double the flights in 2010. Flight test points⁶ accomplished exceeded the plan, overall as shown in figure 3. The flight test points accomplished on the Air Force's conventional takeoff and landing (CTOL) variant were less than planned, due to operating limitations and aircraft reliability.

⁶ Flight test points are specific, quantifiable objectives in flight plans that are needed to verify aircraft design and performance.

Figure 3: 2011 JSF Flight Test Points Progress



Source: GAO analysis of DOD data.

Even with the progress made in 2011, most development flight testing, including the most challenging, still lies ahead. Through 2011, the flight test program had completed 21 percent of the nearly 60,000 planned flight test points estimated for the entire program.⁷ Program officials reported that flight tests to date have largely demonstrated air worthiness, flying qualities, speed, altitude, and maneuvering performance requirements. According to JSF test officials, the more complex testing such as low altitude flight operations, weapons and mission systems integration, and high angle of attack has yet to be done for any variant and may result in new discoveries. Initial development flight tests of a fully

⁷ According to program officials, completion of a test point means that the test point has been flown and that flight engineers ruled that the point has met the need. Further analysis may be necessary for the test point to be closed out.

integrated, capable JSF aircraft to demonstrate full mission systems capabilities, weapons delivery, and autonomic logistics is now expected in 2015 at the earliest. This will be critical for verifying that the JSF aircraft will work as intended and for demonstrating that the design is not likely to need costly changes. Like other major weapon system acquisitions, the JSF will be susceptible to discovering costly problems later in development when the more complex software and advanced capabilities are integrated and flight tested. With most development flight testing still to go, the program can expect more changes to aircraft design and continued alterations of manufacturing processes.

STOVL Issues and Its Probation Period

The STOVL variant performed better than expected in flight tests during 2011. It increased flight test rates and STOVL-specific mode testing, surpassing planned test point progress for the year. Following reliability problems and performance issues, the Secretary of Defense in January 2011 had placed the STOVL on “probation” for two years, citing technical issues unique to the variant that would add to the aircraft’s cost and weight. The probation limited the U.S. STOVL procurement to three aircraft in fiscal year 2011 and six aircraft in fiscal year 2012 and decoupled STOVL testing from CV and CTOL testing so as not to delay those variants. While no specific exit criteria was defined, the two year probation was expected to provide enough time to address STOVL-specific technical issues, engineer solutions, and assess their impact.

In January 2012, the Secretary of Defense lifted the STOVL probation after one year, citing improved performance and completion of the initial sea trials as a basis for the decision. The Department concluded that STOVL development, test, and product maturity is now comparable to the other two variants. While several technical issues have been addressed and some potential solutions engineered, assessing whether the deficiencies are resolved is ongoing and, in some cases, will not be known for years. According to the program office, two of the five specific problems cited are considered to be fixed while the other three have temporary fixes in place. The Director, Operational Test and Evaluation reported that significant work remains to verify and incorporate modifications to correct known STOVL deficiencies and prepare the system for operational use. Until the proposed technical solutions have been fully tested and demonstrated, it cannot be determined if the technical problems have been resolved.

Software and Mission Systems Represent Significant Risks

Software providing essential JSF capability has grown in size and complexity, and is taking longer to complete than expected. Late releases of software have delayed testing and training, and added costs. Software defects, low productivity, and concurrent development of successive blocks have created inefficiencies, taking longer to fix defects and delaying the demonstration of critical capabilities. The program has modified the software development and integration schedule several times, in each instance lengthening the time needed to complete work. In attempting to maintain schedule, the program has deferred some capabilities to later blocks. Deferring tasks to later phases of development adds more pressure and costs to future efforts and likely increases the probability of defects being realized later in the program, when the more complex capabilities in these later blocks are already expected to be a substantial technical challenge.

The lines of code necessary for the JSF's capabilities have now grown to over 24 million—9.5 million on board the aircraft. By comparison, JSF has about 3 times more on-board software lines of code than the F-22A Raptor and 6 times more than the F/A-18 E/F Super Hornet. This has added work and increased the overall complexity of the effort. The software on-board the aircraft and needed for operations has grown 37 percent since the critical design review in 2005. While software growth appears to be moderating, contractor officials report that almost half of the on-board software has yet to complete integration and test—typically the most challenging phase of software development. JSF software growth is not much different than other recent defense acquisitions which have experienced from 30 to 100 percent growth in software code over time. However, the sheer number of lines of code for the JSF makes the growth a notable cost and schedule challenge.

JSF's mission systems⁸ and logistics systems are critical to realizing the operational and support capabilities expected by the warfighter, but the hardware and software for these systems are immature and unproven at this time. Only 4 percent of mission systems requirements have been verified and significant learning and development remains before the program can demonstrate mature software and hardware. The program

⁸ Mission systems provide combat effectiveness through next generation sensors with fused information from on-board and off-board systems (i.e., Electronic Warfare, Communication Navigation Identification, Electro-Optical Target System, Electro-Optical Distributed Aperture System, Radar, and Data Links).

has experienced significant technical challenges developing and integrating mission and logistics systems software and hardware, including problems with the radar, integrated processor, communication and navigation equipment, and electronic warfare capabilities.

- Problems with the helmet mounted display may pose the greatest risk. The helmet is integral to fusing and displaying sensor and weapons employment data, providing situational awareness, and reducing pilot workload. Helmet shortfalls—including night vision capability, display jitter (varying image), and latency (or delay) in transmitting data—could limit capability or change operational concepts. DOD is pursuing a dual path by funding a less-capable alternate helmet as a back-up; this development effort will cost more than \$80 million. The selected helmet will not be integrated with the baseline aircraft until 2014 or later, increasing the risks of a major system redesign, retrofits of already built aircraft, or changes in concepts of operation.
- The Autonomic Logistics Information System (ALIS) is a ground system essential to managing and streamlining logistics and maintenance functions and for controlling life-cycle operating and support costs. ALIS is also not mature and may require some design changes to address known deficiencies. ALIS is in limited operations at test and training sites and officials are evaluating proposed solutions. While additional development time and resources may resolve some deficiencies, several requirements are not going to be met given current schedules, according to the JSF test team report.

Initial dedicated operational testing of a fully integrated JSF is tentatively scheduled to begin in 2017. Operational testing is important for evaluating the warfighting effectiveness and suitability of the JSF, and successfully completing initial operational testing is required to support the full rate production decision, now expected in 2019. Operational testers assessed progress of JSF development testing and its readiness for operational testing, and concluded that the program was not on track to meet operational effectiveness or suitability requirements. The test team's October 2011 report identified deficiencies with the helmet mounted display, night vision capability, aircraft handling characteristics, and shortfalls in maneuvering performance. The report also cited an inadequate logistics system for deployments, excessive time to repair and restore low observable features, low reliability, and poor maintainability performance. It also stated that the JSF will require substantial improvements in order to achieve sortie generation rates and life cycle cost requirements.

Contract Overruns and Concurrency Costs Indicate the Program Has Not Yet Stabilized Design and Manufacturing

The program has not yet demonstrated a stable design and manufacturing processes capable of efficient production. Engineering changes are persisting at relatively high rates and additional changes will be needed as testing continues. Manufacturing processes and performance indicators show some progress, but performance on the first four low-rate initial production contracts has not been good. All four have experienced cost overruns and late aircraft deliveries. In addition, the government is also incurring substantial additional costs to retrofit produced aircraft to correct deficiencies discovered in testing. Until manufacturing processes are in control and engineering design changes resulting from information gained during developmental testing are reduced, there is risk of more cost growth. Actions the Department has taken to restructure the program have helped, but remaining concurrency between flight testing and production continues to put cost and schedule at risk. Even with the substantial reductions in near-term procurement quantities, DOD is still investing billions of dollars on hundreds of aircraft while flight testing has years to go.

Cost Overruns and Delivery Delays Indicate Need to Further Mature the Manufacturing Process

As was the experience with building the development test aircraft, manufacturing the procurement aircraft is costing more and taking longer than planned. Cost overruns and delivery slips are two indicators that manufacturing processes, worker efficiency, quality control, and supplier performance are not yet sufficiently capable to handle the volume of work scheduled. Cost overruns on each of the first four annual procurement contracts are projected to total about \$1 billion (see table 2).

Table 2: Procurement Contract Costs as of November 2011

Dollars in millions

Contract	Number of aircraft	Contract cost at award	Current contract cost estimate	Cost increase	Percent increase
LRIP 1	2	\$511.7	\$561.5	\$49.8	9.7
LRIP 2	12	\$2,278.5	\$2,607.7	\$329.2	14.4
LRIP 3	17	\$3,154.2	\$3,569.5	\$415.3	13.2
LRIP 4	32	\$3,458.3	\$3,703.3	\$245.0	7.1
Total	63	\$9,402.7	\$10,442.0	\$1,039.3	11.1

Source: GAO analysis of DOD data.

Note: LRIP is low-rate initial production. These are the first four annual procurements.

According to program documentation, through the cost sharing provisions in these contracts, the government's share of the total overrun is about \$672 million. On average, the government is paying an additional \$11 million for the 63 aircraft on under contract (58 are U.S. aircraft and 5 are for international partners). There is risk of additional cost overruns because all work is not completed. Defense officials reduced the buy quantity in the fifth annual procurement contract to help fund these cost overruns and additional retrofit costs to fix deficiencies discovered in testing.

While Lockheed Martin, the prime contractor, is demonstrating somewhat better throughput capacity and showing improved performance indicators, the lingering effects of critical parts shortages, out of station work⁹, and quality issues continue to be key cost and schedule drivers on the first four production lots. Design modifications to address deficiencies discovered in testing, incorporation of bulkhead and wing process improvements, and production of the first carrier variant further impacted manufacturing during 2011. Lockheed had expected to deliver 30 procurement aircraft by the end of 2011 but delivered only nine procurement aircraft. Each was delivered more than 1 year late. The manufacturing effort still has thousands of aircraft planned for production over the next 25 years and the rate of production is expected to increase substantially starting in 2015. This will make it vital that the contractor achieve an efficient manufacturing process.

Pratt & Whitney, the engine manufacturer, had delivered 42 production engines and 12 lift fans at the time of our review.¹⁰ Like the aircraft system, the propulsion system is still under development working to complete testing and fix deficiencies while concurrently delivering engines under the initial procurement contracts. The program office's estimated cost for the system development and demonstration of the engine has increased by 75 percent, from \$4.8 billion to \$8.4 billion, since the start of development. Engine deliveries continue to miss expected contract due dates but still met aircraft need dates because of longer slips in aircraft

⁹ Out of station work occurs when manufacturing steps are not completed at its designated work station and must be finished elsewhere later in production. This is highly inefficient, increasing labor hours, causing delays, and sometimes quality problems.

¹⁰ Note: The prime engine contractor has production contracts with the government and the engines are provided as government furnished equipment to the JSF prime contractor.

production. Supplier performance problems and design changes are driving cost increases and late engines. Lift fan system components and processes are driving the major share of cost and schedule problems.

Going forward, Lockheed Martin's ability to manage its expanding global supplier network is fundamental to meeting production rates and throughput expectations. DOD's Independent Manufacturing Review Team earlier identified global supply chain management as the most critical challenge for meeting production expectations. The cooperative aspect of the supply chain provides both benefits and challenges. The international program structure is based on a complex set of relationships involving both government and industry from the United States and eight other countries. Overseas suppliers are playing a major and increasing role in JSF manufacturing and logistics. For example, center fuselage and wings will be manufactured by Turkish and Italian suppliers, respectively, as second sources. In addition to ongoing supplier challenges—parts shortages, failed parts, and late deliveries—incorporating international suppliers presents additional challenges. In addition, the program must deal with exchange rate fluctuations, disagreements over work shares, technology transfer concerns, different accounting methods, and transportation requirements that have already caused some delays. Also, suppliers have sometimes struggled to develop critical and complex parts while others have had problems with limited production capacity. Lockheed Martin has implemented a stricter supplier assessment program to help manage supplier performance.

Testing and Production Overlap Increases Engineering Changes and Concurrency Costs

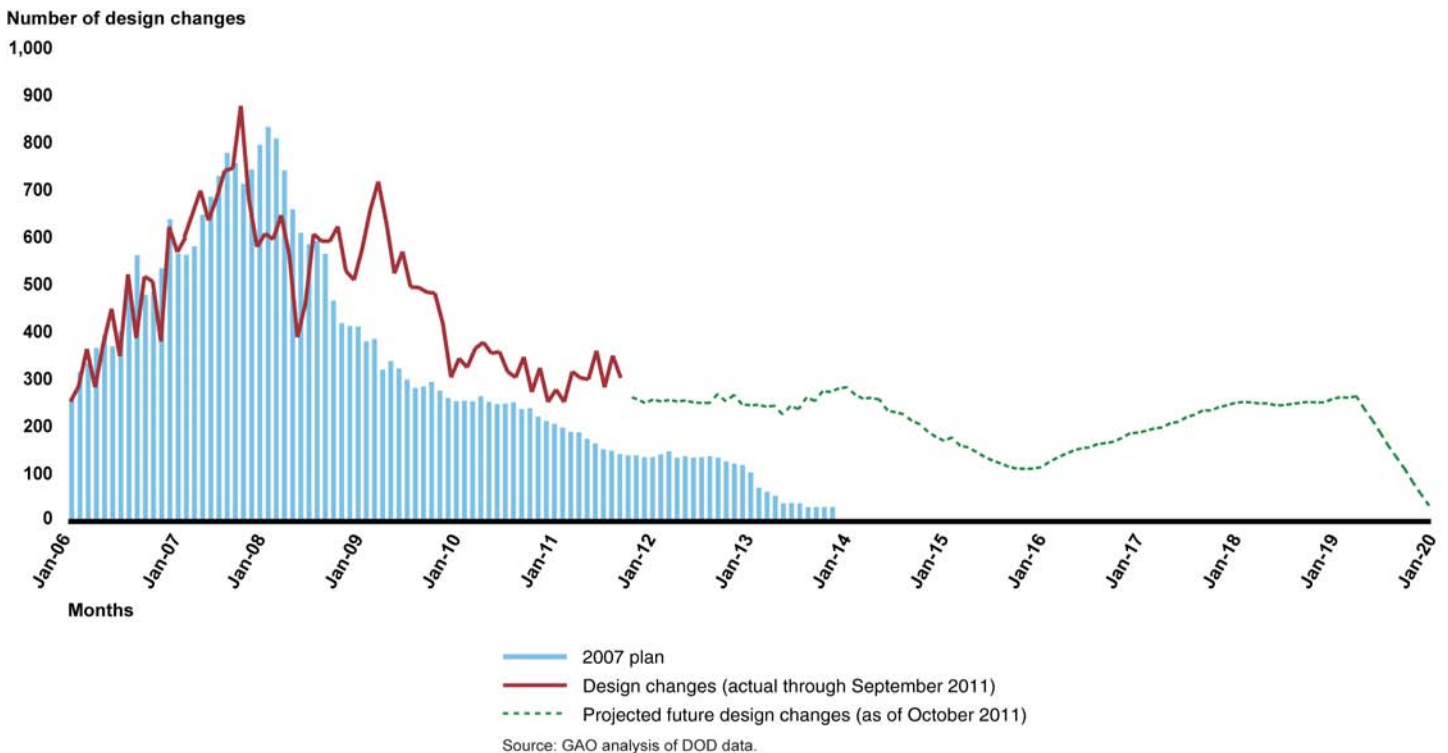
We and several defense offices cautioned the Department years ago about the risks posed by the extremely high degree of concurrency, or overlap, among the JSF development, testing, and production activities.¹¹ To date, the Government has incurred an estimated \$373 million in retrofit costs on already-built aircraft to correct deficiencies discovered in development testing. This is in addition to the \$672 million for the government's share of contract cost overruns. The program office projects additional retrofit costs through lot 10, but at decreasing amounts. Questions about who will pay for additional retrofit costs under

¹¹ GAO, *Joint Strike Fighter: DOD Plans to Enter Production before Testing Demonstrates Acceptable Performance*, [GAO-06-356](#) (Washington, D.C.: Mar. 15, 2006) and GAO, *Joint Strike Fighter: Progress Made and Challenges Remain*, [GAO-07-360](#) (Washington, D.C.: Apr. 2, 2007).

the planned fixed price contracts—the contractor or the government—and how much, have delayed final contract negotiations on the fifth lot.

Producing aircraft before testing sufficiently demonstrates the design is mature increases the likelihood of future design changes, which drives cost growth, schedule delays, and manufacturing inefficiencies. Design changes needed in one JSF variant could also impact the other two variants, reducing efficiencies necessary to lower production and operational costs with common parts and manufacturing processes for the three variants. While the JSF program's engineering change traffic—the monthly volume of changes made to engineering drawings—is declining, it is still higher than expected for a program entering its sixth year of production. The total number of engineering drawings continues to grow due to design changes, discoveries during ground and flight testing, and other revisions to drawings. Figure 4 tracks design changes over time and shows that changes are expected to persist at an elevated pace through 2019.

Figure 4: JSF Design Changes Over Time



Defense officials have long acknowledged the substantial concurrency built into the JSF acquisition strategy, but until recently stated that risks were manageable. However, a recent high-level departmental review of JSF concurrency determined that the program is continuing to discover issues at a rate more typical of early design experience, questioning the assumed design maturity that supported the highly concurrent acquisition strategy.¹² DOD's November 2011 report concluded that the "team assesses the current confidence in the design maturity of the F-35 to be lower than one would expect given the quantity of LRIP aircraft procurements planned and the potential cost of reworking these aircraft as new test discoveries are made. This lack of confidence, in conjunction with the concurrency driven consequences of the required fixes, supports serious reconsideration of procurement and production planning." The review identified substantial risk of needed modifications to already produced aircraft as the flight testing enters into more strenuous test activities. Already, as a result of problems found in less strenuous basic airworthiness testing, critical design modifications are being fed back through the production line. For example, the program will be cutting in aircraft modifications to address bulkhead cracks discovered during airframe ground testing and STOVL auxiliary inlet door durability issues. More critical test discoveries are likely as the program moves into the more demanding phases of testing.

Restructuring actions by the Department since early 2010 have provided the JSF program with more achievable development and production goals, and has reduced, but not eliminated, risks of additional retrofit costs due to concurrency in current and future lots. The Department has progressively lowered the production ramp-up rate and cut near term procurement quantities; fewer aircraft procured while testing is still ongoing lowers the risk of having to modify already produced aircraft. However, even with the most recent reductions in quantities, the program will still procure a large number of aircraft before system development is complete and flight testing confirms that the aircraft design and performance meets warfighter requirements. Table 3 shows the current plan that will procure 365 aircraft for \$69 billion by the end of planned developmental flight tests.

¹² *F-35 Joint Strike Fighter Concurrency Quick Look Review*, Office of the Under Secretary of Defense for Acquisition, Technology and Logistics, Nov. 29, 2011.

Table 3: JSF Procurement Investments and Flight Test Progress

fiscal years	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Cumulative procurement (billions of dollars)	\$0.8	\$3.5	\$7.1	\$14.3	\$21.3	\$27.6	\$33.8	\$40.1	\$47.9	\$57.8	\$69.0
Cumulative aircraft procured	2	14	28	58	90	121	150	179	223	289	365
Percentage of total planned flight tests completed (est.)	<1	<1	<1	1	5	17	32	52	72	91	100

Source: GAO analysis of DOD budget and test plan data.

Note: Advanced procurement funding from 2006 was incorporated into fiscal year 2007 total funding, as 2007 was the first year of aircraft procurement. Flight testing data reflect the percentage of the total flight test completed at the time of the planned investment decision, which is the beginning of the fiscal year.

Concluding Observations

Over the last 2 years, the JSF program has undergone extensive restructuring that places it on a more achievable course, albeit a lengthier and more expensive one. At the same time, the near-constant churn (change) in cost, schedule, and performance expectations has hampered oversight and insight into the program, in particular the ability to firmly assess progress and prospects for future success. Going forward, it will be imperative to bring stability to the program and provide a firm understanding of near- and far-term financial requirements so that all parties—the Congress, Defense Department, and international partners—can reasonably set priorities and make informed decisions amid a tough fiscal environment.

The JSF remains the critical centerpiece of DOD's long-term tactical aircraft portfolio. System development of the aircraft and engine ongoing for over a decade, continue to experience significant challenges. The program's strategic framework, laden with concurrency, has proved to be problematic and ultimately, a very costly approach. DOD over the past year has identified substantial cost overruns attributed to relatively poor execution in production and specific concurrency-related inefficiencies. There is risk of future cost growth from test discoveries driving changes to design and manufacturing processes. Effectively managing software and the global supply chain is critical to improving program outcomes, increasing manufacturing throughput, and enabling future expansion of JSF procurement.

Chairman Bartlett, Ranking Member Reyes, and members of the House Armed Services Committee, this completes my prepared statement. I would be pleased to respond to any questions you may have. We look forward to continuing to work with the Congress as we finalize our upcoming report with potential new recommendations that will address these issues in more detail.

GAO Contacts and Acknowledgments

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Related GAO Products

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